



WHAT IS CLAIMED IS:

- 1 1. A method for measuring the mass of a substance, the method
2 comprising:
3 applying energy to a substance;
4 measuring a response resulting from the application of energy; and
5 determining the mass of the substance based on the measured response.
- 1 2. A method as in claim 1, further comprising volumetrically
2 metering the substance prior to applying the energy.
- 1 3. A method as in claim 2, wherein the substance comprises a
2 powder, and wherein the metering step comprises depositing the powder within a
3 metering chamber.
- 1 4. A method as in claim 1, wherein the energy applying step
2 comprises directing electromagnetic radiation onto the substance.
- 1 5. A method as in claim 1, wherein the energy applying step
2 comprises directing light onto the substance.
- 1 6 A method as in claim 5, wherein the measuring step comprises
2 measuring light transmitted through the substance, and wherein the determining step
3 comprises correlating the measured light with an associated mass.
- 1 7. A method as in claim 5, wherein the measuring step comprises
2 measuring light emitted from the substance, and wherein the determining step comprises
3 correlating the measured light with an associated mass.
- 1 8. A method as in claim 5, wherein the measuring step comprises
2 measuring an interference pattern caused by transmitted or emitted light from the
3 substance interfering with the light directed onto the substance, and wherein the
4 determining step comprises correlating the interference pattern with an associated mass.
- 1 9. A method as in claim 1, wherein the energy applying step
2 comprises applying current or voltage to the substance, wherein the measuring step
3 comprises measuring the impedance of the substance, and wherein the determining step
4 comprises correlating the impedance with an associated mass.



1 10. A method as in claim 1, wherein the energy applying step
2 comprises applying vibrational energy to the substance, and wherein the measuring step
3 comprises measuring the energy dissipation caused by the substance.

1 11. A method as in claim 10, wherein the step of applying vibrational
2 energy comprises vibrating a piezoelectric element to subject the substance to pressure
3 changes, wherein the measuring step comprises measuring the vibrational frequency of
4 the piezoelectric element after energy has been dissipated by the substance, and wherein
5 the determining step comprises comparing the measured vibrational frequency with a
6 natural oscillating frequency of the piezoelectric element, and correlating the change in
7 frequency with an associated mass.

1 12. A method as in claim 1, further comprising comparing the
2 determined mass with a range of masses that defines an acceptable unit mass range to
3 determine whether the measured substance is within the acceptable range.

1 13. A method as in claim 1, further comprising processing the response
2 using tomography.

1 14 ~~134~~. A method for determining whether a metered volume of a
2 substance contains a unit mass, the method comprising;
3 filling a metering chamber defining a certain volume with a substance;
4 applying energy to the substance while within the metering chamber;
5 measuring a response resulting from the application of energy; and
6 determining the mass of the substance based at least in part on the
7 measured response.

1 15 ~~145~~. A method as in claim 14, further comprising comparing the
2 determined mass with a range of masses that defines an acceptable unit mass range to
3 determine whether the determined mass falls within the acceptable range.

1 16 ~~15~~. A method as in claim 14, further comprising ejecting the substance
2 from the metering chamber, and applying the energy and measuring the response while
3 the ejected powder is traveling away from the metering chamber.



1 ~~17~~ ¹⁶. A method for measuring the mass of a substance, the method
2 comprising:
3 directing a beam of radiation onto a substance;
4 measuring the transmittance or emittance of radiation from the substance,
5 or an interference pattern caused by transmitted or emitted radiation from the substance
6 interfering with the beam; and
7 determining the mass of the substance based at least in part on the
8 measured transmittance or emittance of radiation, or the interference pattern.

1 ~~18~~ ¹⁷. A method as in claim 17, further comprising depositing the
2 substance within a metering chamber and passing the beam through the metering
3 chamber.

1 ~~19~~ ¹⁸. A method as in claim 18, wherein the substance comprises a
2 powder, and wherein the depositing step comprising drawing the powder into the
3 metering chamber with a vacuum.

1 ~~20~~ ¹⁹. A method as in claim 17, further comprising comparing the
2 determined mass with a range of masses that defines an acceptable unit mass range to
3 determine whether the measured substance is within the acceptable range.

1 ~~21~~ ²⁰. A method for determining whether a unit mass of a substance has
2 been metered, the method comprising:
3 passing a calibrating beam of radiation at a certain intensity through a
4 metering chamber that defines a certain volume;
5 measuring the intensity of the calibrating beam after passing through the
6 chamber;
7 filling the chamber with a substance;
8 passing a measuring beam of radiation at the certain intensity through the
9 substance;
10 measuring the intensity of the measuring beam after passing through the
11 substance;
12 determining the transmittance of the measuring beam through the
13 substance; and



14 determining the mass of the substance based at least in part on the
15 transmittance of the measuring beam.

1 ~~22~~ 21. A method as in claim 21, wherein the transmittance is determined
2 by subtracting the measured intensity of the measuring beam from the measured intensity
3 of the calibrating beam.

1 ~~23~~ 22. A method as in claim 21, wherein the substance comprises a
2 powder, and wherein the depositing step further comprises drawing a vacuum within the
3 metering chamber to assist in capturing falling powder into the chamber.

1 ~~24~~ 23. A method as in claim 23, wherein the metering chamber includes a
2 filter upon which the substance rests, and further comprising passing the calibrating beam
3 and the measuring beam through the filter.

1 ~~25~~ 24. A method as in claim 23, wherein the metering chamber is included
2 within a rotatable drum, and further comprising rotating the drum between multiple
3 positions where the intensity of the calibrating beam is measured, where the powder is
4 deposited in the chamber, and where the intensity of the measuring beam is measured.

1 ~~26~~ 25. A method as in claim 25, further comprising rotating the drum to
2 another position and ejecting the powder from the chamber and into a receptacle.

1 ~~27~~ 26. A method as in claim 26, further comprising repeating the step of
2 rotating the drum between the multiple positions to deposit another mass of powder into
3 another receptacle.

1 ~~28~~ 27. A method as in claim 21, further comprising comparing the
2 determined mass with a range of masses that defines an acceptable unit mass range to
3 determine whether the measured substance is within the acceptable range.

1 ~~29~~ 28. A method as in claim 28, further comprising varying the amount of
2 vacuum and/or the rate at which the powder is permitted to fall in a subsequent filling of
3 the metering chamber based on the value of the measured mass in comparison to the
4 acceptable range of masses.



1 ~~30~~ ²⁹. A system for measuring the mass of a substance, the system
2 comprising:
3 a metering chamber that defines a certain volume and that is adapted to
4 receive a substance;
5 an energy source disposed to supply energy to the substance;
6 at least one sensor to measure a response from the substance due to the
7 application of energy from the energy source; and
8 a processor coupled to the sensor to determine a mass of the substance
9 held within the metering chamber based at least in part on the measured response.

1 ~~31~~ ³⁰. A system as in claim 30, wherein the energy source comprises a
2 source of electromagnetic radiation disposed to direct electromagnetic radiation onto the
3 substance.

1 ~~32~~ ³¹. A system as in claim 31, wherein the sensor is selected from a
2 group of sensors consisting of a radiometer and a reflectometer.

1 ~~33~~ ³². A system as in claim 31, wherein the processor is configured to
2 determine the mass of the substance by correlating transmitted or emitted light measured
3 by the sensor with an associated mass.

1 ~~34~~ ³³. A system as in claim 31, wherein the processor is configured to
2 determine the mass of the substance by correlating a measured interference pattern
3 measured by the sensor with an associated mass.

1 ~~35~~ ³⁴. A system as in claim 30, wherein the energy source comprises an
2 electrode that is adapted to pass electrical current through the substance, wherein the
3 sensor comprises a sensing electrode and circuitry to measure the capacitance of the
4 substance.

1 ~~36~~ ³⁵. A system as in claim 30, wherein the energy source comprises a
2 vibratable element that is adapted to apply vibrational energy to the substance, and
3 wherein the sensor is configured to measure an amount of energy dissipation caused by
4 the substance.

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1 36. A system as in claim 36, wherein the vibratable element comprises
2 a piezoelectric element that is adapted to supply pressurize air pulses to the substance,
3 wherein the sensor further comprises circuitry to determine the vibrational frequency of
4 the piezoelectric element after energy has been dissipated by the substance, and wherein
5 the processor is configured to compare the measured vibrational frequency with a natural
6 oscillating frequency of the piezoelectric element, and to correlate the change in
7 frequency with an associated mass.

1 37. A system as in claim 36, wherein the processor is further
2 configured to compare the determined mass with a range of masses that defines an
3 acceptable unit mass range to determine whether the measured substance is within the
4 acceptable range.

1 38. A system for measuring the mass of a substance, the system
2 comprising:
3 a metering chamber that defines a certain volume and that is adapted to
4 receive a substance;
5 a radiation source disposed to pass a beam of radiation through the
6 metering chamber;
7 at least one sensor to detect radiation transmitted or emitted from the
8 substance; and
9 a processor coupled to the sensor to determine a mass of the substance
10 held within the metering chamber based at least in part on the detected radiation.

1 39. A system as in claim 39, wherein the processor is further
2 configured to determine the mass of the substance by associating the loss of transmitted
3 light, an interference pattern, or the stimulation of fluorescence with a stored mass value.

1 40. A system as in claim 40, wherein the processor is configured to
2 determine the loss of transmitted light by comparing an intensity value of the beam after
3 passing through the substance with an intensity value of a beam from the radiation source
4 passing through the chamber in the absence of the substance.

1 41. A system as in claim 39, wherein the metering chamber includes a
2 filter at a bottom end upon which the substance is adapted to rest, and wherein the



3 radiation source is disposed to pass a beam through the filter and then through the
4 chamber.

1 43. 42. A system as in claim 42, further comprising a vacuum source in
2 communication with the chamber to assist in drawing the substance into the chamber.

1 44. 43. A system as in claim 43, further comprising a rotatable drum in
2 which the chamber is disposed, and wherein the radiation source is included within the
3 drum.

1 45. 44. A system as in claim 44, further comprising a powder fluidization
2 apparatus disposed above the drum that is adapted to supply fluidized powder to the
3 chamber.

1 46. 45. A system as in claim 45, further comprising a pair of sensors, and
2 wherein the processor is configured to rotate the chamber past one of the sensors when
3 the chamber is empty of powder, to rotate the chamber into alignment with the powder
4 fluidization device to permit the chamber to be filled with powder, and to rotate the
5 chamber past the other sensor when the chamber is filled with powder.

1 47. 46. A system as in claim 46, further comprising code used by the
2 processor to compare the determined mass of the powder with a range of acceptable mass
3 values, and wherein the processor is configured to alter the amount of vacuum and/or
4 operation of the fluidization apparatus depending on the outcome of the comparison.

1 48. 47. A system as in claim 39, further comprising code used by the
2 processor that includes a relationship between the amount of transmitted light, an
3 interference pattern, or the amount of fluorescence and the associated mass of the
4 substance when the substance fills the chamber.

1 49. 48. A system as in claim 39, wherein the radiation source comprises a
2 laser and wherein the sensor comprises a lens and a radiometer.

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